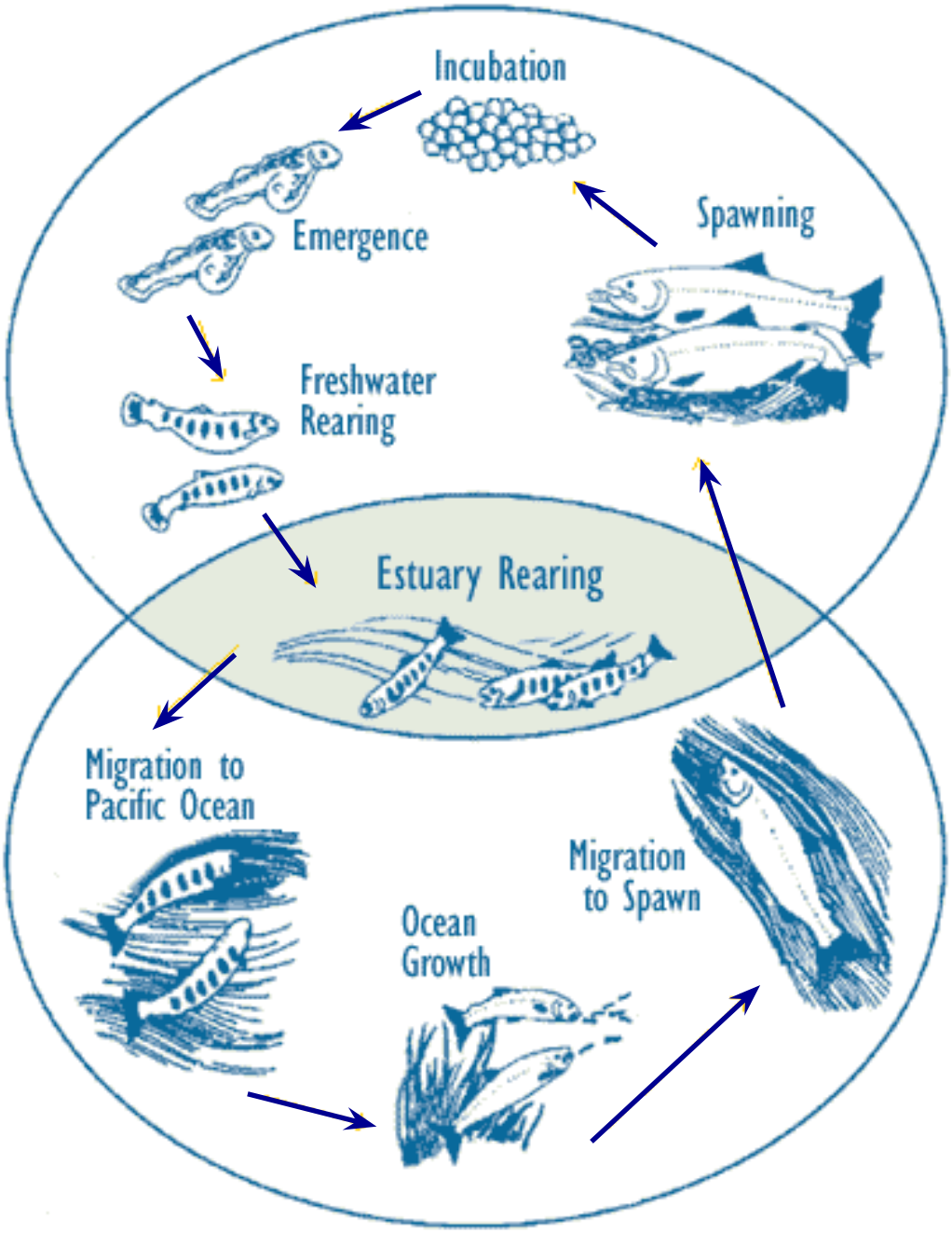
NOAA FISHERIES

SWFSC - FED

4.0 Climate Change and Salmon Recovery Overview

Nate Mantua
Southwest Fisheries Science Center
Santa Cruz, CA

May 4, 2015

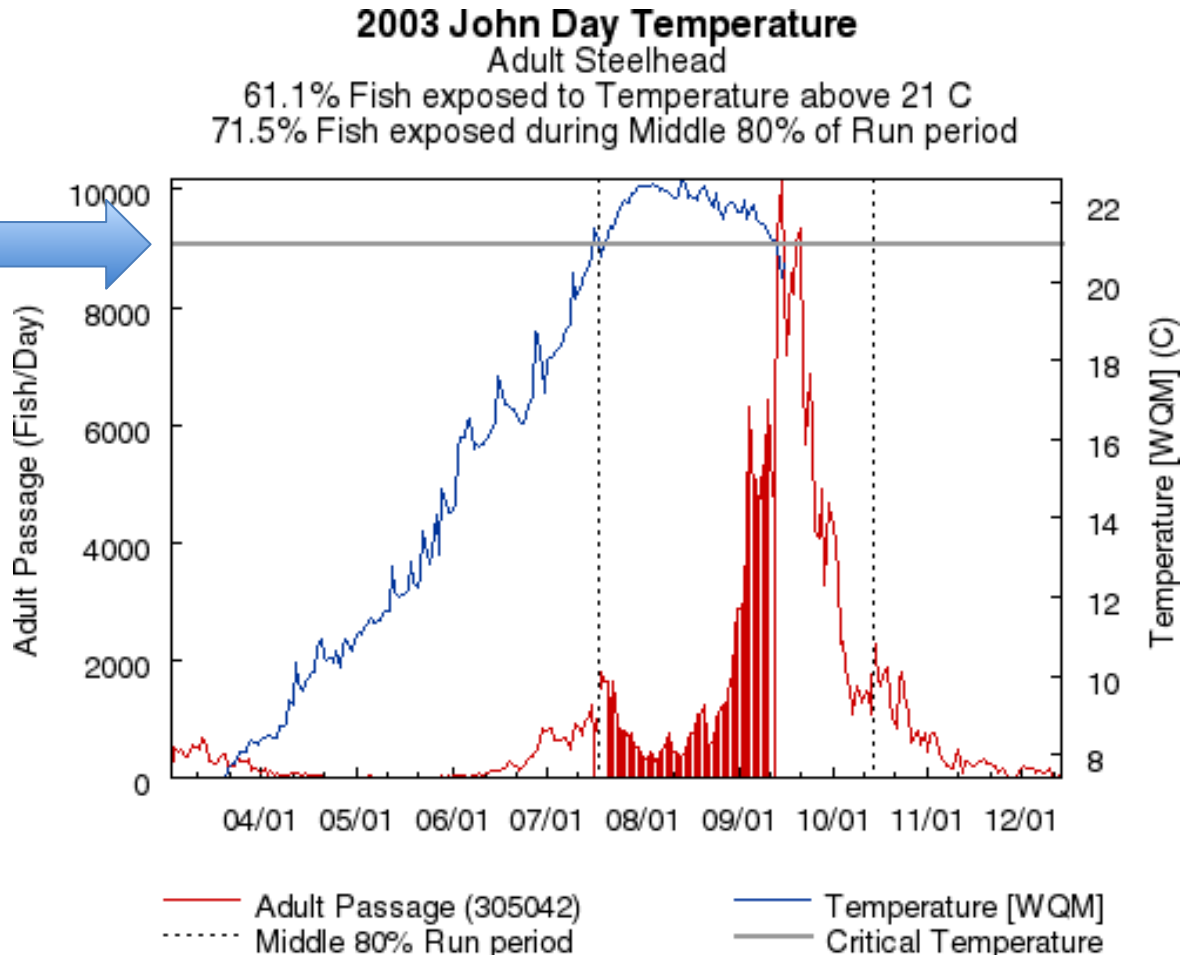


Climate matters for salmon

- complex lifecycle requires a chain of different habitats to be favorable across space-time; sequential habitat needs set by different life history patterns
- flow and temperature are critical climate pressure points in freshwater habitats
- marine food-web is critical for ocean growth

Adult Chinook salmon migration and water temperature in the Lower Columbia River

- **For many West Coast salmon populations, adult spawning migrations are sensitive to water temperatures > ~21ºC**



UW SAFS Columbia Basin DART: http://www.cqs.washington.edu/

Klamath River fish kill 2002 – a case where a short-term drought amplified management-related stresses on cold water

- Disease, high fish densities, low flows and a very warm river combined to result in a massive kill of adult chinook salmon in the lower Klamath River

High-temperature fish kills not unique to the Klamath in 2002

- near miss in 2014?
- 2013 Chinook kill in MF John Day

Pacific Fishery Management Council ***NEWS RELEASE***

FOR IMMEDIATE RELEASE : Thursday, April 10, 2008

Contact: Ms. Jennifer Gilden, Communications Officer, 503-820-2280
Dr. Donald McIsaac, Executive Director, 503-820-2280

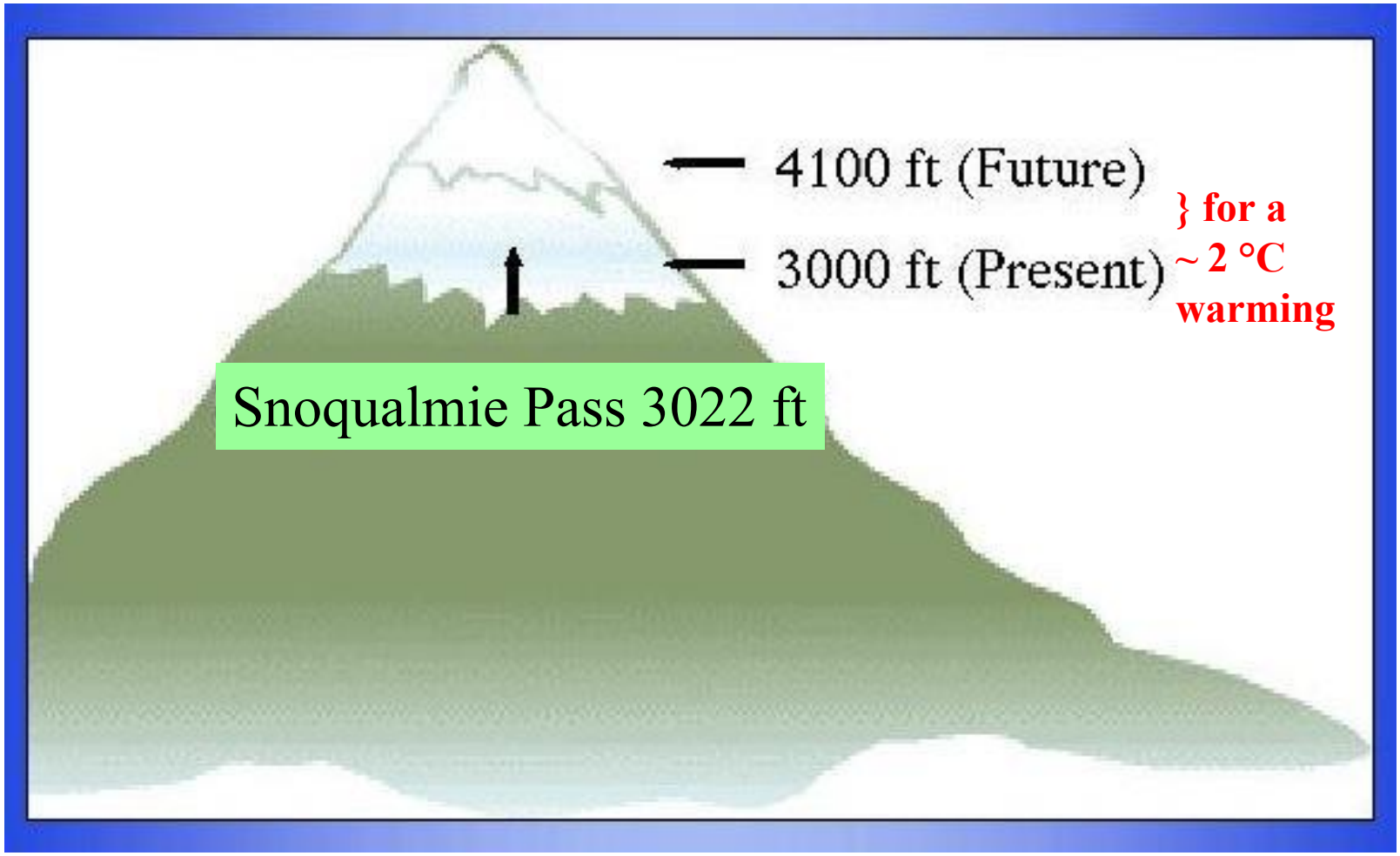
RECORD LOW SALMON FISHERIES ADOPTED

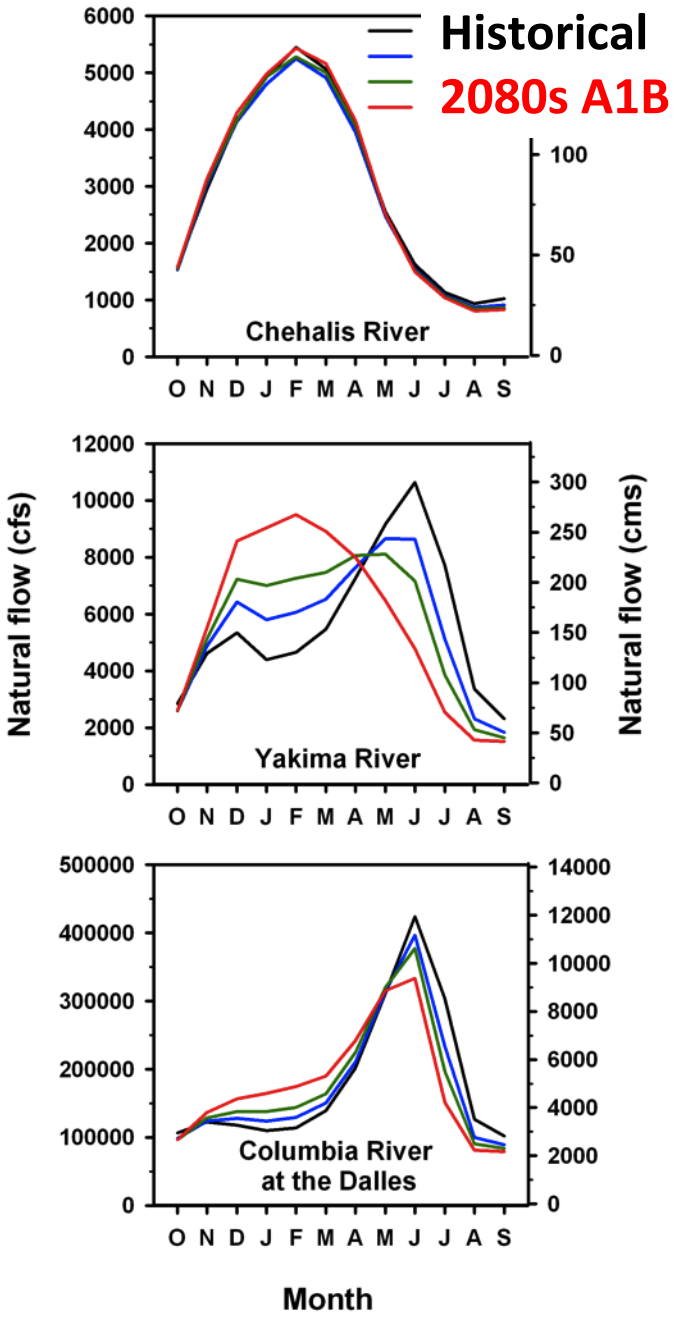
SEATTLE, Wash – The Pacific Fishery Management Council today adopted the most restrictive salmon fisheries in the history for the West Coast, in response to the unprecedented collapse of Sacramento River fall Chinook and the exceptionally poor status of coho salmon from Oregon and Washington. The recommendation will be forwarded to the National Marine Fisheries Service for approval by May 1, 2008.

"This is a disaster for West Coast salmon fisheries, under any standard," said Council chairman Don Hansen. "There will be a huge impact on the people who fish for a living, those who eat wild-caught king salmon, those who enjoy recreational fishing, and the businesses and coastal communities dependent on these fisheries."

- Climate extremes had a hand in this disaster too … this time it was terrible ocean conditions due to delayed upwelling in 2005, and poor upwelling in 2006

A robust impact of climate warming for the west coast US: **less snow**





3 basic streamflow patterns

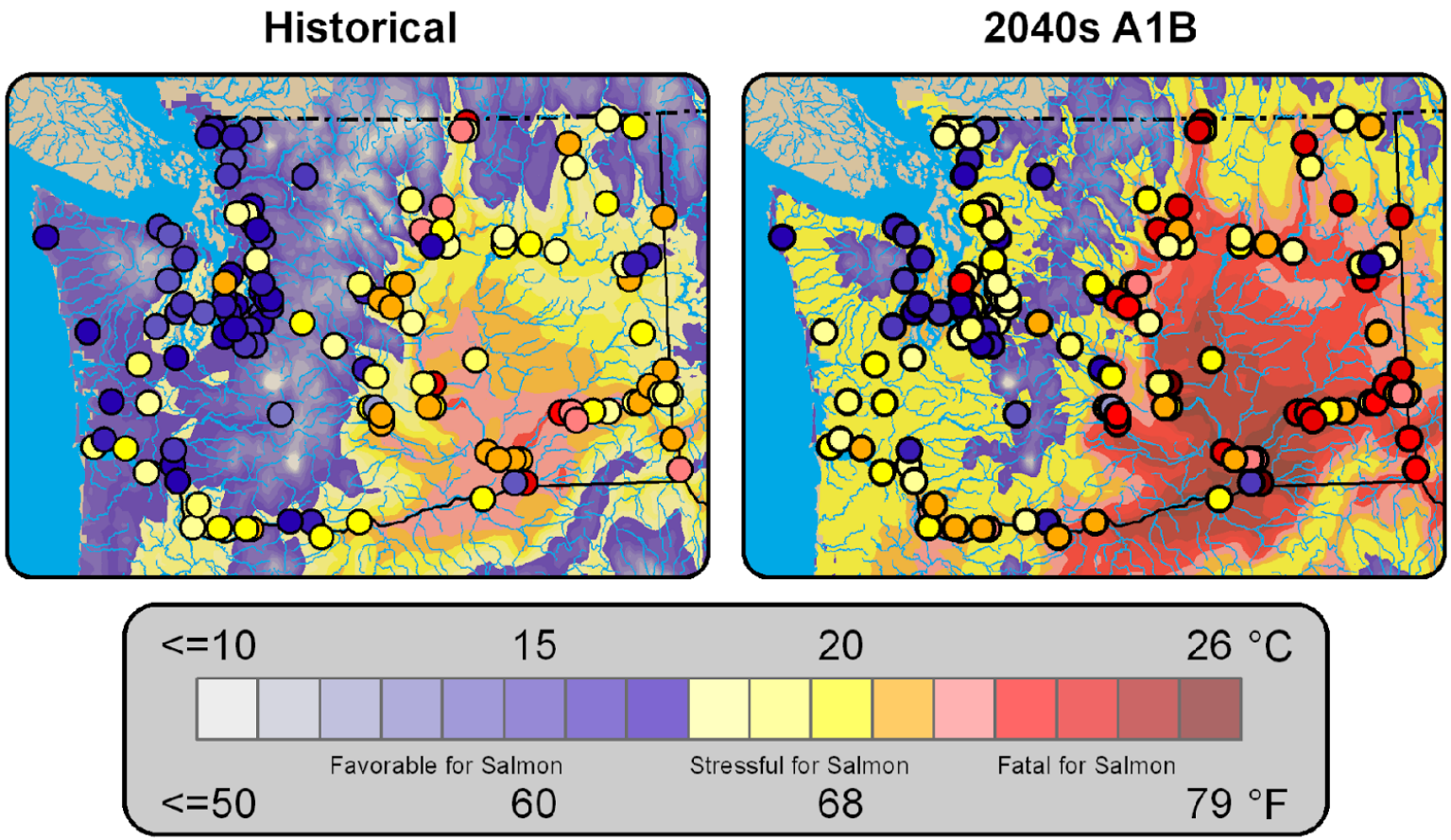
1. ***rain-dominated***

2. "***transient***" runoff basins with an early winter peak from rainfall, and a spring peak from snowmelt

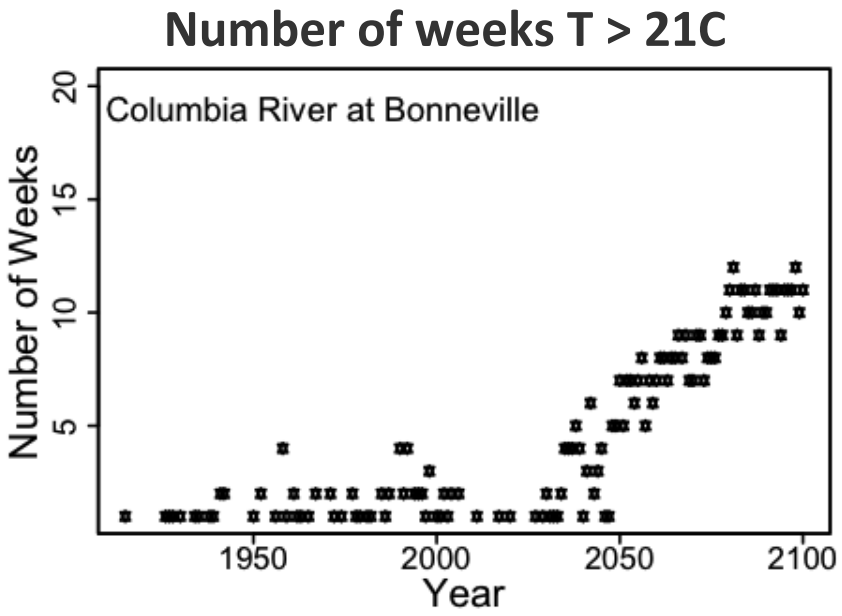
3. ***snowmelt-runoff*** basins, where streamflow peaks in late spring and early summer

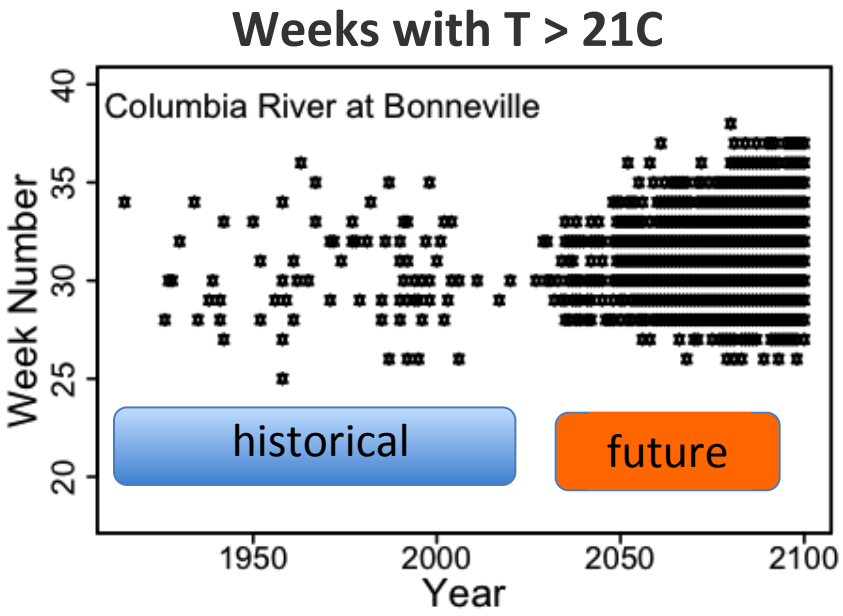
Elsner et al (2010)

Western Washington's "maritime" summer climate becomes as warm as today's interior Columbia Basin, temperatures in the interior Columbia Basin become as warm as today's Central Valley in California



Mantua et al. 2010: Climatic Change





Thermal stress season

- Use a simple regression model to translate future air temperature scenarios into stream temperature scenarios
- Extended periods with weekly average water temperatures > 21C
  - the season of thermal migration barriers for migrating salmon predicted to last up to 12 weeks in the mainstem Columbia River

Mantua et al. 2010: Climatic Change

Key climate change issues for salmon recovery: changes in hydrology, temperatures, and ocean conditions are likely to compound existing stressors on salmon

vulnerability = (sensitivity x exposure)/(adaptive capacity)

- Reduced adaptive capacity due to diminished diversity, abundance, distribution, and productivity
- Sensitivity is especially high for populations using sub-optimal habitats
- Increased exposure due to the cumulative impacts of lost, simplified and degraded habitat due to land/water use actions and hydrologic impacts of a warming climate

Decision-support needs

- Restoration partners and planners, including water managers, are lacking tools, information, and coordination needed for effective recovery actions (water management, habitat restoration, hatchery practices, etc.)
- Targeted science aimed at informing trade-offs over water resources and in related political decisions

What we're doing: Science for Decision Support aimed at effective management actions, including restoration

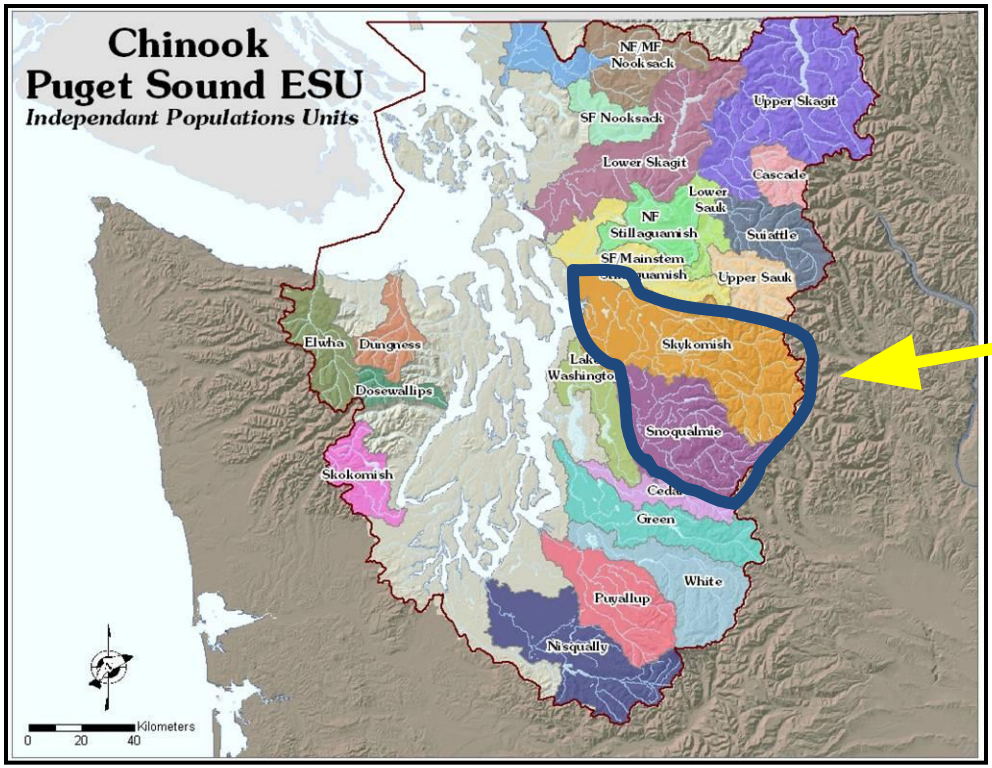
Research to support effective management and restoration actions

- Process-based habitat / physiology / life cycle modeling
- Adaptation / evolution studies through a climate change lens
- Extinction risk studies
- Evaluating impacts of restoration and climate change scenarios
- Developing decision-support tools

Synthesis and Advice

- the recently developed West Coast Climate Team for coordinating climate science and its use in West Coast Regional office
- Supporting biological opinions and recovery plans
- Developing review papers and synthesis papers

Snohomish Basin Case Study



Snohomish R.

- Evaluate the benefits of alternative habitat restoration plans under different future climate scenarios using linked hydrologic and salmon-lifecycle models

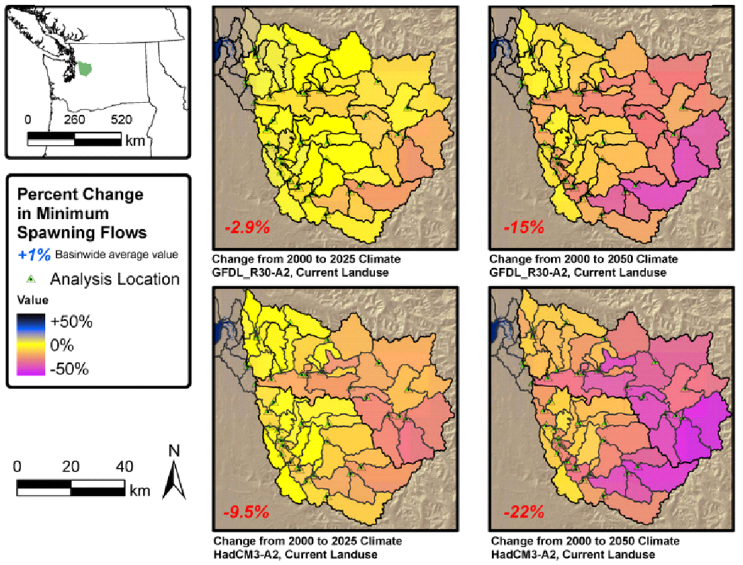
Battin et al. 2007: PNAS

Impacts of Climate Change on Salmon Recovery in the Snohomish River (Battin et al. 2007: PNAS)

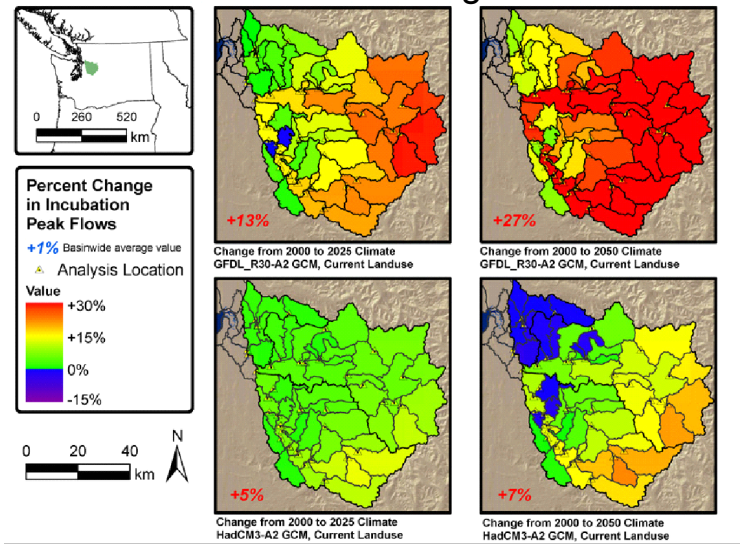
Climate Change will make salmon restoration more difficult:

- Decreasing Summer Low Flows
- Increasing Winter Peak Flows
- Increasing water temperatures in critical periods

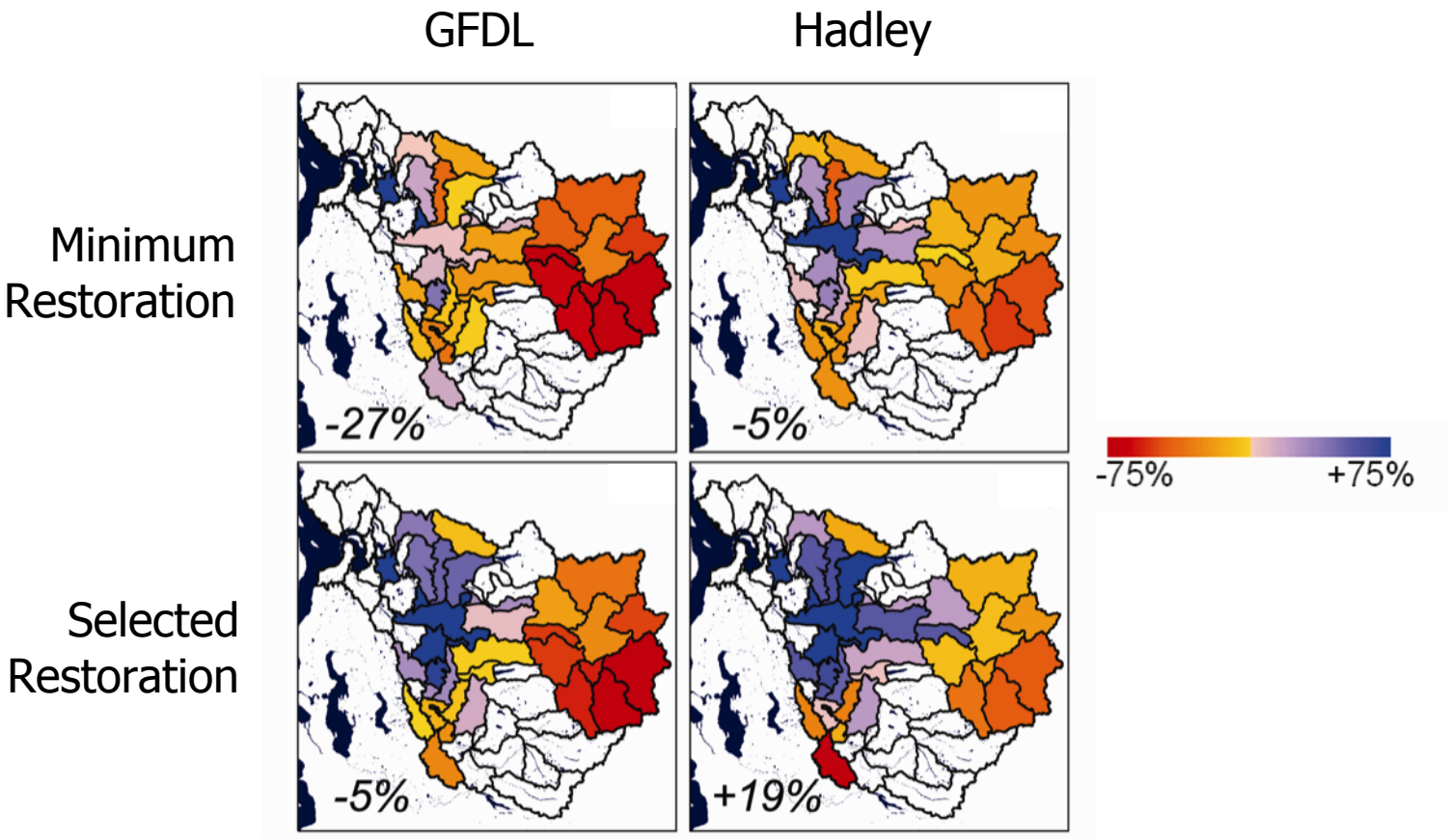
Decreasing Spawning Flows



Increasing Winter Flows



Predicted change in the distribution of wild spawners by 2050



- Negative effects of climate change are concentrated at higher elevations
- Positive effects of restoration are concentrated at lower elevations
- Effects are likely to increase the proportion of Chinook spawning at lower elevations

50 YEARS WITH IMPACT
Journal of Applied Ecology
British Ecological Society
Journal of Applied Ecology 2013, 50, 1093–1104
doi: 10.1111/1365-2664.12137

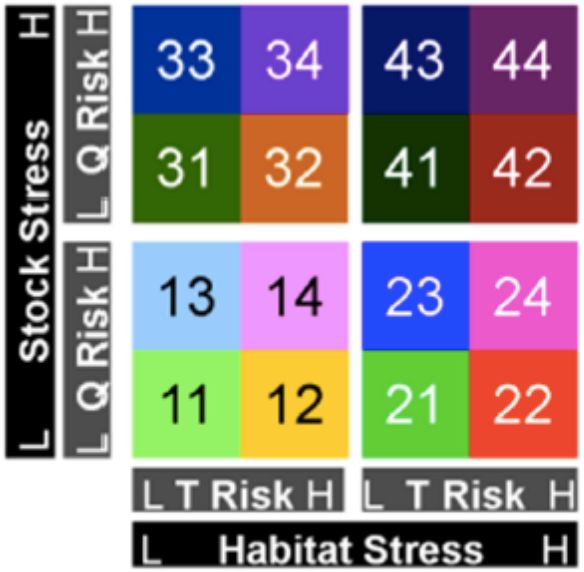
Steelhead vulnerability to climate change in the Pacific Northwest

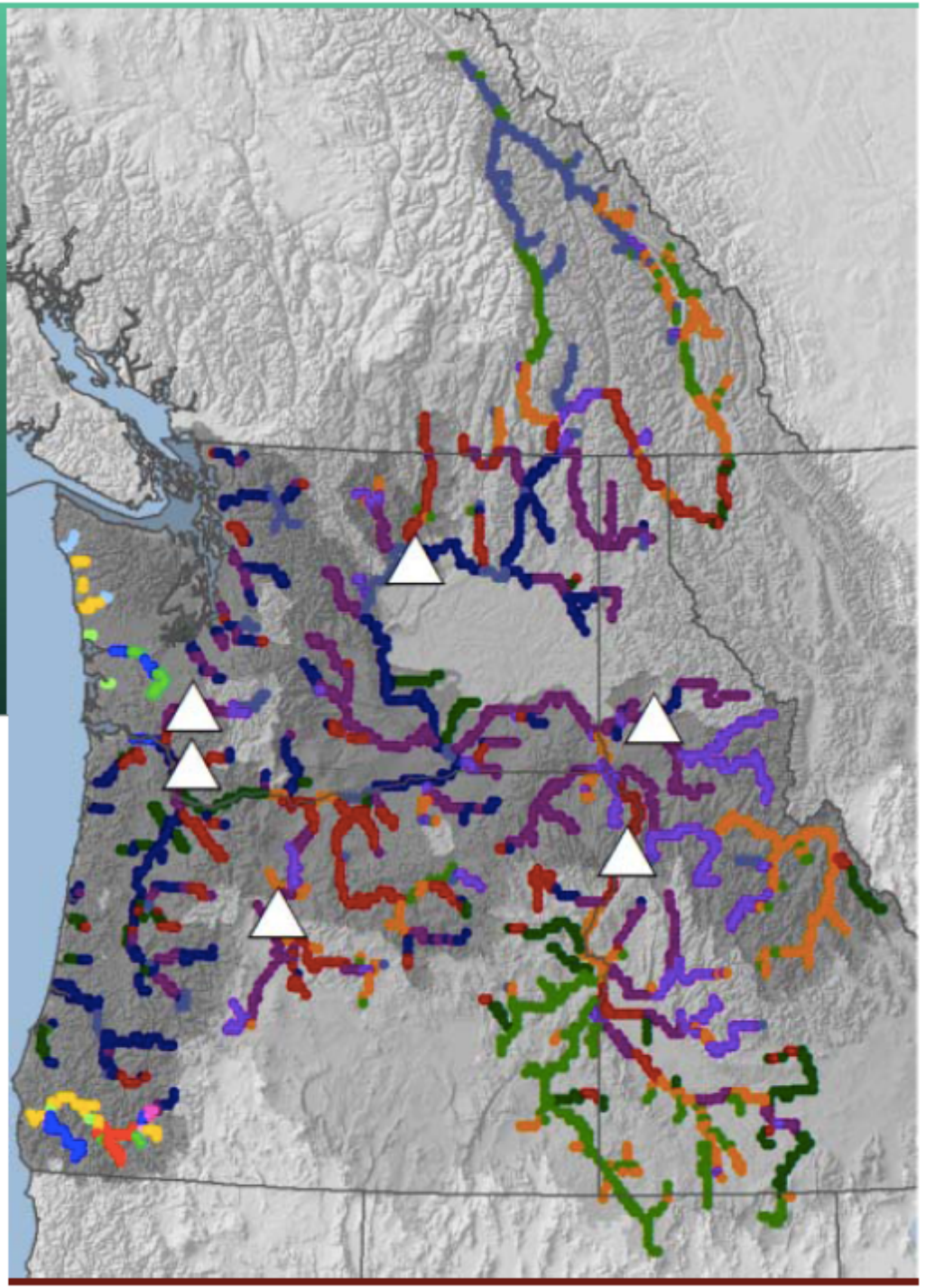
Alisa A. Wade[1*,†], Timothy J. Beechie[2], Erica Fleishman[3], Nathan J. Mantua[4], Huan Wu[5‡], John S. Kimball[5], David M. Stoms[6] and Jack A. Stanford[5]

- "*Exposure*" informed by future stream flow and stream temperature scenarios
- "*sensitivity/adaptive capacity*" informed by habitat and stock condition (VSP parameters and NMFS status reviews)
- Allowed for a spatially and population specific assessment of key factors underlying vulnerability
  - For some cases, assessment highlights vulnerability related to increased spawning flows, or warming migration temperatures … in others, key factor is poor habitat and/or stock status leading to very high sensitivity / low adaptive capacity

PNW Steelhead Vulnerability

exposure x sensitivity (2080)





RESTORING SALMON HABITAT FOR A CHANGING CLIMATE

T. BEECHIE[a*], H. IMAKI[a], J. GREENE[a], A. WADE[b], H. WU[c,d], G. PESS[a], P. RONI[a], J. KIMBALL[e], J. STANFORD[e], P. KIFFNEY[a] AND N. MANTUA[f]

River Research and Applications (2012)

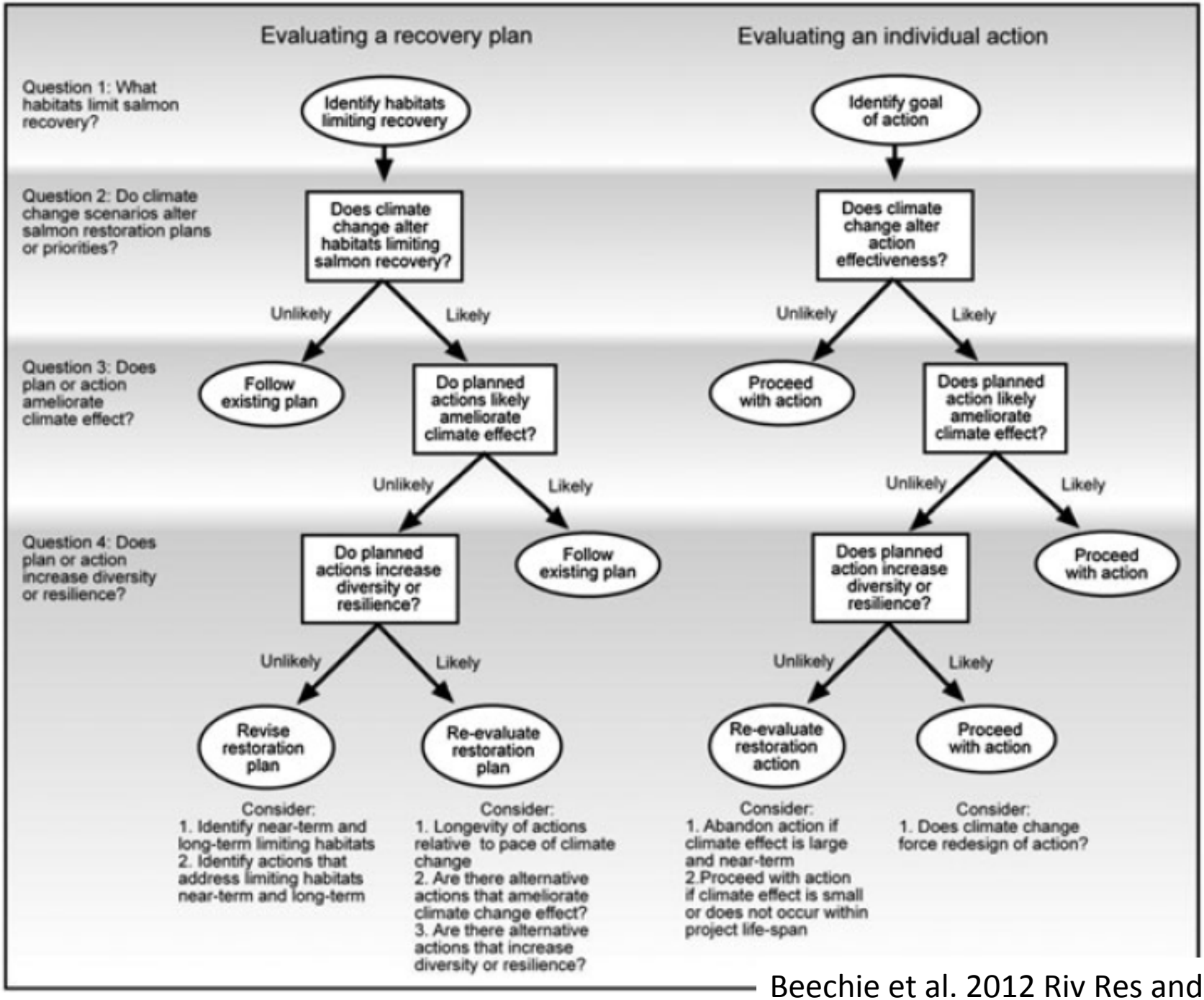
How should habitat restoration plans be altered to accommodate climate change effects on stream flow and temperature?

- We developed a decision-support process for adapting recovery plans that incorporates (1) local habitat factors limiting salmon recovery, (2) scenarios of climate change impacts on flow and temperature, (3) the ability of restoration actions to ameliorate climate change effects, and (4) the ability of restoration actions to increase habitat diversity and salmon population resilience

Restoration actions and their ability to ameliorate climate impacts

Category	Common techniques	Ameliorates temperature increase	Ameliorates base flow decrease	Ameliorates peak flow increase	Increases salmon resilience
Longitudinal connectivity (barrier removal)					
	Removal or breaching of dam	●	●	○	●
	Barrier or culvert replacement/removal	○	○	○	●
Lateral connectivity (floodplain reconnection)					
	Levee removal	●	○	●	●
	Reconnection of floodplain features (e.g. channels, ponds)	●	○	●	●
	Creation of new floodplain habitats	●	○	●	●
Vertical connectivity (incised channel restoration)					
	Reintroduce beaver (dams increase sediment storage)	●	●	●	●
	Remove cattle (restored vegetation stores sediment)	●	●	●	○
	Install grade controls	●	●	●	○
Stream flow regimes					
	Restoration of natural flood regime	●	●	○	◒
	Reduce water withdrawals, restore summer baseflow	●	●	○	○
	Reduce upland grazing	○	◒	◒	○
	Disconnect road drainage from streams	○	○	●	○
	Natural drainage systems, retention ponds, other urban stormwater techniques	○	◒	●	○

Beechie et al. 2012: Riv. Res. and Appl.



Beechie et al. 2012 Riv Res and Appl

Conservation Biology Special Issue on Climate Change and the ESA

Synthesis and Advice

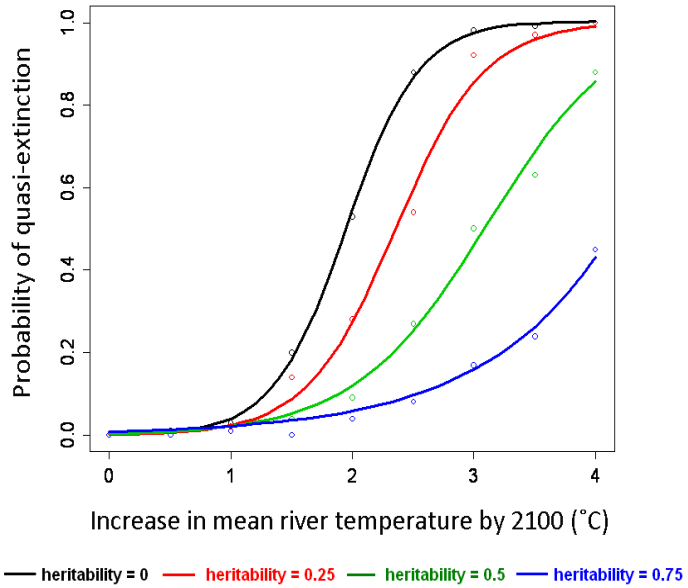
- Incorporating Climate Science in Applications of the U.S. Endangered Species Act for Aquatic Species (McClure et al. 2013)
- Choosing and Using Future Climate Change Scenarios for Impacts Assessment (Snover et al. 2013)

Research

- Impacts of water diversion and climate change on Chinook Salmon in the Lemhi Basin (Walters et al. 2013)
- Floodplain Rehabilitation as a Hedge against Hydroclimatic Uncertainty in a Migration Corridor of Threatened Steelhead (Boughton and Pike 2013)

Research themes: adaptation and evolution

- 2006 Seattle workshop and special issue
- IBM for evaluating role of heritability in upstream migration timing in extinction risk under varying temperature scenarios (Reed et al 2011)
- Empirical studies: evolutionary and plastic responses to environmental change: case study of Columbia Basin sockeye return timing (Crozier et al. 2011)
- Synthesis/review papers



Effects of evolution on quasi-extinction risk for a modeled population of sockeye salmon that experience warming temperatures in the Fraser River (Reed et al. 2012)

Synthesis and Advice:
West Coast Region Climate Team

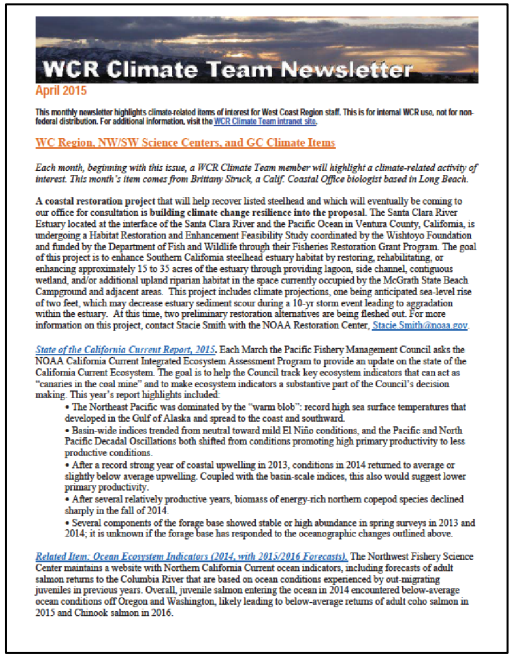
Composed of Regional Office, Science Center, General Counsel, and Restoration Center representatives

Purposes:

- Promote consistent treatment of climate change in WCR analyses and decisions.
- Provide access to climate change information, training opportunities and tools, for all staff.
- Coordinate WCR responses to NOAA and NMFS HQ requests.
- Coordinate WCR interactions with other agencies and groups involved in climate change research and management activities.

Some Team Activities:

- Monthly meetings to share information among Science Centers, WCR divisions, external guests, etc.
- Monthly newsletter with new information and resources for staff
- Developing guidance to address climate change in ESA consultations (biological opinions)
- Incorporating climate change considerations into revised fish passage guidelines
- Regional representation and coordination on HQ projects:
    - e.g., NMFS Climate/ESA policy; NMFS Climate Science Strategy; NMFS Climate Vulnerability Analyses; Sustaining Marine Ecosystems in a Changing Climate



WCR Climate Team Newsletter

April 2015

This monthly newsletter highlights climate-related items of interest for West Coast Region staff. This is for internal WCR use, not for non-federal distribution. For additional information, visit the WCR Climate Team intranet site.

WC Region, NW/SW Science Centers, and GC Climate Items

Each month, beginning with this issue, a WCR Climate Team member will highlight a climate-related activity of interest. This month's item comes from Brittany Struck, a Calif. Coastal Office biologist based in Long Beach.

A coastal restoration project that will help recover listed steelhead and which will eventually be coming to our office for consultation is building climate change resilience into the proposal. The Santa Clara River Estuary located at the interface of the Santa Clara River and the Pacific Ocean in Ventura County, California, is undergoing a Habitat Restoration and Enhancement Feasibility Study coordinated by the Wishtoyo Foundation and funded by the Department of Fish and Wildlife through their Fisheries Restoration Grant Program. The goal of this project is to enhance Southern California steelhead estuary habitat by restoring, rehabilitating, or enhancing approximately 15 to 35 acres of the estuary through providing lagoon, side channel, contiguous wetland, and/or additional upland riparian habitat in the space currently occupied by the McGrath State Beach Campground and adjacent areas. This project includes climate projections, one being anticipated sea-level rise of two feet, which may decrease estuary sediment scour during a 10-yr storm event leading to aggradation within the estuary. At this time, two preliminary restoration alternatives are being fleshed out. For more information on this project, contact Stacie Smith with the NOAA Restoration Center, Stacie.Smith@noaa.gov

State of the California Current Report, 2015. Each March the Pacific Fishery Management Council asks the NOAA California Current Integrated Ecosystem Assessment Program to provide an update on the state of the California Current Ecosystem. The goal is to help the Council track key ecosystem indicators that can act as "canaries in the coal mine" and to make ecosystem indicators a substantive part of the Council's decision making. This year's report highlights included:

- The Northeast Pacific was dominated by the "warm blob": record high sea surface temperatures that developed in the Gulf of Alaska and spread to the coast and southward.
- Basin-wide indices trended from neutral toward mild El Niño conditions, and the Pacific and North Pacific Decadal Oscillations both shifted from conditions promoting high primary productivity to less productive conditions.
- After a record strong year of coastal upwelling in 2013, conditions in 2014 returned to average or slightly below average upwelling. Coupled with the basin-scale indices, this also would suggest lower primary productivity.
- After several relatively productive years, biomass of energy-rich northern copepod species declined sharply in the fall of 2014.
- Several components of the forage base showed stable or high abundance in spring surveys in 2013 and 2014, it is unknown if the forage base has responded to the oceanographic changes outlined above.

Related Item: Ocean Ecosystem Indicators (2014, with 2015/2016 Forecasts). The Northwest Fishery Science Center maintains a website with Northern California Current ocean indicators, including forecasts of adult salmon returns to the Columbia River that are based on ocean conditions experienced by out-migrating juveniles in previous years. Overall, juvenile salmon entering the ocean in 2014 encountered below-average ocean conditions off Oregon and Washington, likely leading to below-average returns of adult coho salmon in 2015 and Chinook salmon in 2016.

Climate Change in salmon recovery plans

Very little or no Climate Change Info (2005-2009): Lake Ozette sockeye, Puget Sound Chinook; Upper Columbia Steelhead; Upper Columbia Chinook.

Some Climate Info, Could Use Updating (2009): Middle Columbia R. steelhead.

Substantial Info Provided (**2013-2014**): Columbia River chum; Lower Col. R. Chinook; Lower Col R. steelhead; Lower Col R. coho South-Central CA Coast steelhead; S. CA steelhead; CC coho; Sacramento Winter-run Chinook; Central Valley Spring-run Chinook; Central Valley steelhead; Central CA coast coho; SONCC coho.

In Development: CA Coastal Chinook; C.CA Coast steelhead; N. CA Coast steelhead; Oregon Coast coho; Snake River sockeye, Snake River steelhead; Snake River spring/summer Chinook; Snake River fall Chinook.

What we could be doing for Climate Change and Salmon Recovery

- Climate change vulnerability assessments for salmon populations in specific watersheds, ESUs and/or regions (like Wade et al.)

- Identifying climate change refugia for specific watersheds, ESUs and/or regions
  - we are currently developing, testing, and using methods for quantifying spawning and rearing habitat capacities in currently inaccessible habitats (behind high dams) on the upper Merced and Tuolumne Rivers to inform reintroduction decisions

- Climate change and salmon predator studies

- More work on climate change and salmon ocean ecology

Future Challenges

Maintaining momentum after the crisis of the day passes

- Current CA drought has led to new funding, more hires, and more research activity. Can we maintain this momentum going forward?

Making progress on ocean ecology and climate change

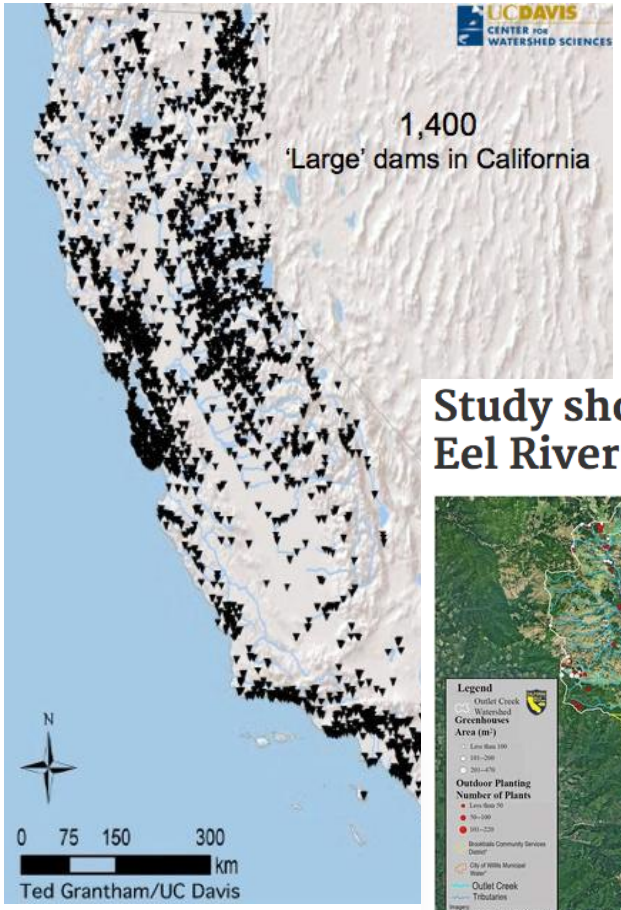
- hampered by the lack of key pieces that include: understanding more details of salmon ocean ecology, complexity of marine food webs, a lack of published work on future ocean conditions (physical, chemical, biological, and food webs) – in NOAA's wheelhouse!

Coordination within NOAA line offices

- for instance, having NOAA's OAR and NMFS make climate change and west coast ocean conditions a research priority

Drought impacts on California's salmon and steelhead

Dams, diversions, habitat degradation and drought, together, have severely degraded the productive capacity of California's streams and estuaries for salmon and steelhead



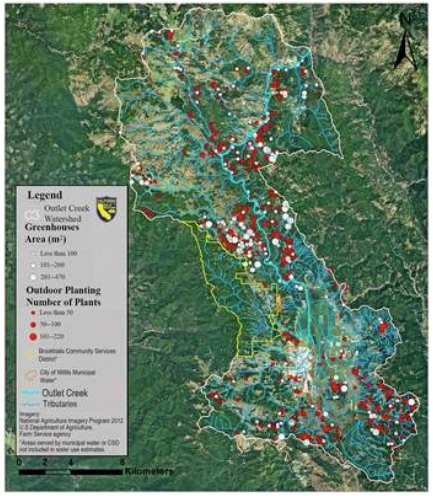
Low stream flows and high stream temperatures are bad news for salmon and steelhead … the lack of abundant stream flow is causing intense conflicts among competing user groups

DROUGHT

CA's environmental water use scrutinized

Brown administration says environmental flows already cut back

Study shows marijuana is sucking the Eel River dry



Chinook salmon eggs didn't hatch, hatchery fish come to rescue

abc7 NEWS
SAN FRANCISCO • OAKLAND • SAN JOSE

SECTIONS TRAFFIC VIDEO San Francisco East Bay

BREAKING NEWS Missing 8

WEATHER

DROUGHT BRINGS DOUBLE DOSE OF DAMAGE TO COHO SALMON

Conservation Biology

Special Section

Choosing and Using Climate-Change Scenarios for Ecological-Impact Assessments and Conservation Decisions

AMY K. SNOVER,* ‡‡ NATHAN J. MANTUA,*† JEREMY S. LITTELL,*‡ MICHAEL A. ALEXANDER,§ MICHELLE M. MCCLURE,** AND JANET NYE††

Snover et al. (2013): *Conservation Biology,* **27**: 1147–1157. doi: 10.1111/cobi.12163

- Literature synthesis to support objective approaches to choosing and using future climate scenarios
- Addresses common misconceptions about the accuracy and utility of climate change projections
- Provides structured approach & general guidelines for C&U scenarios
- Examples from marine science, ESA-relevant assessments and others